

The students of High Tech High have written a beautiful, inspiring and fascinating book that mines the rich history of San Diego Bay. This book explores the hidden connections that link every one of us to nature, each other and the past. The stories in this book will surprise you—and spark your curiosity about the secret history of your own corner of the world.”—Erika Check, Senior reporter, *Nature*



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 San Diego Bay: A Story of Exploitation and Restoration
 Ballast Point 1913, San Diego Historical Society
 Northeast Regional Archive
 High Tech High

The Wyland Foundation has always strived to give younger students the drive to use arts and sciences in their quest to understand the environment. This book represents the next step in that progression—solid research by high school students to understand the ever-changing world around them. I not only commend the work of these educators and their students, I applaud it.”—Wyland, Environmental Artist, www.wyland.com

A High Tech High student production published by California Sea Grant, University of California

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San Diego Bay: A Story of Exploitation and Restoration

by the students of GARY AND JERRI-ANN JACOBS HIGH TECH HIGH

SAN DIEGO BAY

A STORY OF EXPLOITATION AND RESTORATION



by the students of
 GARY AND JERRI-ANN JACOBS
 HIGH TECH HIGH

Foreword by Jane Goodall

Praise for *San Diego Bay: A Story of Exploitation and Restoration*

"A creative and thorough portrayal of marine resource utilization in San Diego. This is a wonderful book about San Diego history; that it was written by high school students makes it all the more remarkable. Everybody should have a copy if for no other reason than to appreciate what young scholars can accomplish."—**Paul Dayton**, Ph.D., Biological Oceanographer/Ecologist, Scripps Institution of Oceanography

"What is 'pristine'? This is a question that all conservationists face in today's heavily exploited and sometimes restored world. In producing a book like *San Diego Bay: A Story of Exploitation and Restoration*, the students of High Tech High have not only created a valuable starting point for knowing the historical ecology of San Diego Bay, they have also shown that high school students can take a genuinely leading role in understanding our relationship to nature."

—**Randy Olson**, Director, Shifting Baselines Ocean Media Project, www.shiftingbaselines.org

"*San Diego Bay: A Story of Exploitation and Restoration* is a well-researched book that provides in-depth coverage of the history of the Bay and its use and exploitation by humans from the earliest Native American settlers to the present. The compelling interviews range from the nostalgic remembrances of old tuna fishermen to NOAA scientists conducting "state of the art" assessments of the resources in the Bay today. The students of High Tech High have created a high-quality resource for anyone concerned about the conservation of our bays."—**Louisa Koch**, Education Director and Director/Chair, Education Council, National Oceanic and Atmospheric Administration

"The students of High Tech High have done a remarkable job of revealing a little known and underappreciated aspect of San Diego's past—its strong technology-based roots. These roots are the foundation for our region's high-growth economy today. I applaud their contribution in telling our story as it should be told."—**Joe Panetta**, CEO and President, BIOCUM

Front cover photo: Guy Bruni; cover design: Joann S. Furse and Steve Gabrysh, California Sea Grant College Program

More Praise for *San Diego Bay: A Story of Exploitation and Restoration*

"I was so impressed with *Perspectives of San Diego Bay: A Field Guide*, that I doubted another book about the Bay would be needed. I was wrong, of course, in that the Field Guide is mostly about the present and *San Diego Bay: A Story of Exploitation and Restoration* is mostly about the past and future of the Bay. This book is a thoughtful collection of environmental lessons learned from the history of the Bay by students who have inherited the problems of the past but remain hopeful of its future. Both books are essential reading for a complete understanding of San Diego and its Bay."

—**Michael W. Hager**, President and CEO, San Diego Natural History Museum

"As an educator and author dedicated to supporting schools and students to create high-quality projects, I can think of no more compelling example than the High Tech High field guide *San Diego Bay: A Story of Exploitation and Restoration*. It is a stunning example of the professional quality work that students are capable of doing when trusted and supported to engage in important work for an authentic audience. Combining original scientific and historical research, written with exacting standards and a youthful voice, this book is exciting for San Diego and significant nationally as a model of what high school students can achieve. Every high school in America should own a copy and initiate a similar project in its local environment."—**Ron Berger**, School Designer, Expeditionary Learning Schools

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SAN DIEGO BAY

A STORY OF EXPLOITATION AND RESTORATION



San Diego Waterfront 1890, San Diego Historical Society

by the students of
**THE GARY AND JERRI-ANN JACOBS
HIGH TECH HIGH**

Designed and Edited by
Natalie Linton and Gwen Michael-Jones

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Foreword



the Jane Goodall Institute

San Diego Bay: A Story of Exploitation and Restoration is a wonderful book. It will be hard for the reader to believe that it is based on the research results of a group of high school students. This book demonstrates clearly that young people, when motivated and inspired by outstanding teachers and mentors, have the ability to make major contributions to our understanding of the damage that we have inflicted on the environment and the steps that can be taken to put things right. Much of the thinking behind this truly unique book is grounded in traditional classroom teaching in the disciplines of biology, math and the humanities. This was interwoven with an innovative hands-on approach pioneered by Jay Vavra and his dedicated group of High Tech High (HTH) school students. Jay introduced the Jane Goodall Institute's Roots & Shoots program to HTH students and, incorporating its philosophy into their studies, they have conducted an in-depth, multi-faceted study of the San Diego Bay area. With Jay's vision, the support of dedicated teachers Tom Fehrenbacher, Rod Buenviaje, and an energetic, imaginative and extremely creative group of students, the original idea—learning about the problems of San Diego Bay through hands-on study—has expanded far beyond its original scope. *San Diego Bay: A Story of Exploitation and Restoration* is the outcome. This is not just a field guide, nor is it just a biological study. It provides meticulous descriptions of the flora and fauna that inhabit San Diego Bay. It describes the long-lasting effects that certain human activities have had upon these animals and plants. The students have used traditional scientific methodology, the careful collection and analysis of data, enriching their research, and adding to its veracity, through the use of GIS technology. In addition, they researched the history of human activities in and around the Bay and conducted their own interviews with selected individuals whose experience and knowledge could help to shed new light onto aspects of their investigations.

These students have also researched the age-old human drive to exploit the natural world for increased material wealth and the power that this can bring to the exploiters. The consequences, for the environment, have often been dire in the Bay. And these facts are presented as part of a much wider picture of the effect of human greed and short-sightedness on environments around the globe. Much of this information is depressing—human impact on the Bay and the surrounding habitats has, in many cases, been truly devastating. But the students have also collected information on a whole variety of restoration projects undertaken by the government, industry or concerned individuals trying to make amends. And each chapter provides an inspiring account of one or more of the successful activities of this sort. These stories of hope are particularly encouraging as we are

given information about new approaches, based on new understanding of the problems and the technology and/or perseverance needed to overcome them. Thus there is an important nature center, a refuge for waterfowl and other salt marsh dwellers, where during World War I the area was used to turn kelp into—of all things—explosives for the Allied Forces! And now it is a place where children can learn about the wonders of the natural world and, at the same time, about the indignities that humans have inflicted on it. Then there is the story of the one-time seabass spearfisherman who now manages the seabass breeding program that is helping to restore the species. What I find particularly appealing are the personal reflections of the students—the young people who have, through no fault of their own, inherited a damaged world. In this book we are moved by their poetry, their opinions based on painstaking research and acquired knowledge. Some of these reflections are uncomfortable for us and challenging. These High Tech High students stand united with thousands of other committed young people who have learned, through their Roots & Shoots experience, the importance of using their lives to try to make the world a better place for people, animals and the environment. These are the young leaders of today who will soon be moving out into the adult world, armed with facts and not just theories, citizens who will be prepared to find solutions for difficult problems by keeping open minds, listening to the different opinions, and then making decisions based on an understanding of the whole picture. These students know when to stop talking, roll up their sleeves and take action. Immeasurable value is added to this book by the beautiful descriptive writing. It is rare these days to find young people who can compose clear prose. And this is made even more appealing by the students' photographs and sketches that accompany the writing.

It is immensely reassuring to me, as I travel the globe 300 days a year, to know that the energy, enthusiasm and passions of youth can, under the mentorship of dedicated and wise adults like Jay, Tom, and Rod, lead to the production of a book like this, a book that is both informed and beautiful—that contains science laced with humanity. It gives me reason for hope. Hope for the future of our much-abused planet. Hope that the youth of today will be better stewards than we have been. Hope that, together, we can gradually restore the health of this planet we share.

*Dr. Jane Goodall, DBE
Founder – the Jane Goodall Institute &
UN Messenger of Peace
www.janegoodall.org
www.rootsandshoots.org*

Introduction

We hope the readers of this book will find in its chapters an original story, beautifully told. In the following pages, we have sought to relate stories of San Diego Bay's biological exploitation, record interviews of the people who conducted the harvest, document the industrialization of the natural habitat and in some cases interviewed individuals involved in the recovery of the resource. We have also attempted to chart evidence of their impact and reflect upon their significance. Our students have explored the biological resources of San Diego Bay by addressing the Bay's ecology from a historical perspective. By examining history, we discovered together the dramatic changes that have occurred over time in the Bay's ecology, as well as the past's continuing influence and explanatory power for the present. This approach brought to light the concept of "shifting baselines," as well as the need to recognize and attempt to establish the population decline of species, including the state of marine ecosystems well before our relative short stay on this planet.

San Diego is well known for its thriving, modern, biotechnological industry. Within our community, scientists have successfully established thriving pharmaceutical, medical diagnostic and bioprocessing and bioprospecting ventures. Few individuals, however, are aware of the early experimentation and exploitation that pioneered the biotech industry in San Diego. San Diego Bay and the surrounding near-shore habitats have served as a wonderful laboratory for the exploration of marine resources and their benefits. An important and yet unknown example of early bioprocessing was the exploitation of kelp for gunpowder and explosives that took place during WWI in the lower reaches of the Bay. Local industry also exploited the same fast-growing kelp for its alginates used in many things from food preparation to paint stabilization. In more recent times, little mention or focus has been placed on other explorations in the development of new biological and marine resources. For instance, few give adequate credit to the utilization of marine mammals for the benefit of humanity being conducted by the U.S. Navy.

Like the twelve hours of a clock, this book spins around twelve selected topics involving the exploitation of marine resources in and around San Diego Bay. We followed each story chronologically from the earliest human contact, through Spanish and Mexican California, to an eventual arrival at the dramatic changes of our last century and a half. We discovered in our work a pattern of human interaction: initial contact characterized by unfamiliarity, learning, and exuberant harvest; to a slow, at times fluctuating, depletion; to an eventual and optimistic transformation story. We found in the conclusion to these stories the possibility of a sustainable relationship with our environment. Thus, each story provided us with

both a point of caution and advice as well as hope, which is revealed in the human ability to exploit, yet restore. While the clock may be ticking, by making ourselves aware of the hour, we may still have time to keep our relationship with nature alive.

This book, *Exploitation and Restoration*, is the third in an ongoing series of books on San Diego Bay produced by this teaching team and their innovative, creative and skilled 11th-grade students. Over the years, the Bay has continued to provide a rich and complex setting for an outdoor classroom. We found in this urban historical ecology project, an essential integration of the biological sciences with the humanities. In this dovetailing of biology and humanities, mathematics became the essential tool, which helped us to quantify and evaluate the many questions arising from each of the Bay's stories. The project allowed our students to explore their environment first hand and to begin to address the problematic separation from our natural surroundings found in the city dweller. By bringing our work to the field, we hoped to address the detachment and devaluation that can result when we lose contact with our natural environment. Finally, through the production of this book, we attempted to provide our students with meaningful work both in its production and appreciation. Sharing our stories, information, and findings with others, from the casual user to the informed specialist, through publication brings about its own importance and reward.

In order to discover the stories within the topics we selected and what the future may hold for each, a variety of research practices were undertaken. Generally this involved extensive literature review, interviews with experts and users of resources, collection of field data and direct observation. We attempted to create a learning environment beyond which students gather simple descriptions of their fellow inhabitants, so often found in the traditional field guide approach. Instead, we followed the lead of Jared Diamond's insightful historical look at human civilization, *Guns, Germs and Steel*. We designed a study of the Bay that examined different biological resources in relationship with the Bay's geography and demography. By doing so, we attempted to understand the dependence, survival and prosperity of human culture upon a successful relationship with nature. While "use has frequently led to abuse," we concluded that our rich biodiversity and geographic complexity is best maintained through preservation, prior to its essential restoration.

The book is full of unique contributions, including original interviews of experts and historical figures, archival photos from shoeboxes and desk drawers, as well as the students' own creations of timelines, maps and visual depictions of population dynamics over time. The vast majority of photos are High Tech High images captured by those involved in this project. Yet, we realized that a valid portrayal of historical ecology could not be represented only by fleeting glimpses of contemporary scenes captured by our cameras. These stories of our past have been accompanied by

carefully selected original photos. The student voice, found in these pages, provides a fresh look that weaves itself into and sheds light upon the views of experts and seasoned veterans. As teachers, we commend our first-time published authors, poets, photographers, cartographers, and editors and thank them for their year of hard work and thoughtful effort.

We would like to thank those who have inspired and supported us and encouraged us to pursue this project. We would like to thank California Sea Grant and the Unified Port of San Diego for monetary support and constructive editorial suggestions. The final informative, rich, and beautiful product that is on these pages would not be possible without the intensive review of the final drafts of this book that was done by the chief student editor, Natalie Linton, in coordination with Kelly Makley of the Environmental Services Division of the Port of San Diego and Marsha Gear and Joann Furse of California Sea Grant Communications at Scripps Institution of Oceanography. We thank the National Education Association for the support of teachers like ourselves and for their vision to provide financial assistance so that teachers can explore. Other financial support came from High Tech High and the Regional Occupational Program, institutions that believe education is best when it is rigorous and meaningful. We continue to be inspired by Dr. Jane Goodall's life's work and her message of hope. Her Roots & Shoots Program continues to demonstrate what youth can achieve and contribute to the health and well being of our planet. Larry Rosenstock and all our colleagues at High Tech High have also made this possible and encouraged its innovation and risk taking.

Jay Vavra, biology teacher

Tom Fehrenbacher, humanities teacher

Rod Buenviaje, mathematics teacher

Gary and Jerri-Ann Jacobs High Tech High, San Diego

Acknowledgements

Such a book would not be possible without extensive community support. This is a story about the people of San Diego Bay, past and present, as much as it is about the creatures. Without the people of the community, it would not have been possible to collect the information necessary to make this book.

First and foremost, on behalf of the students, we must thank our teachers, Rod Buenviaje, Tom Feherenbacher, and Dr. Jay Vavra. Throughout the year, these three helped motivate us and ensure us we were experiencing the true meaning of High Tech High's project-based learning. Their unwavering dedication to this book made us, as students, even more compelled to create a stellar product, which we did.

The ones who literally made the book possible were the students. Each student was involved in this book, with the photography, the writing, the poems, the interviews, even the science experiments; each student contributed their personal style to the book, which truly highlights its uniqueness. The chapter editors helped bring it all together: Darci Daneshvari, Natalie Linton, Schuyler Marquez, Robert Stelmach, Gwen Michael-Jones, Fannie Ngo, Erin Rexin, Jane Jensen, Amelia Pludow, and Alan Shirey.

The lives of the earliest inhabitants of the Bay were understood with the help of Steve Bouscaren, Anthropology Professor at San Diego City College; Louis Guassac, a member of the Kumeyaay Nation and Founder of Guassac and Associates; and Patricia Masters, a paleobiologist at the Scripps Institution of Oceanography, who supplied us with an informative interview and allowed us to reproduce her maps of the ancient Bay. Special thanks to Dr. Bouscaren for his multiple interviews and for sharing literature with us. We would also like to thank Andy Yatsko, the archaeologist and Cultural Resources Program Manager who laid the foundation to study the artifacts found at Ballast Point. Special thanks to Ron May, the Director of the Fort Guijarros Museum Foundation, who not only provided us with two interviews, but also allowed us to photograph artifacts within the museum collection, along with Maisie Morris, Lab Supervisor. Dr. May contributed extensively to the editing of the Native American chapter. Thanks to these experts we gained a greater understanding and deeper respect of the Native Americans of San Diego.

Extensive knowledge and historical artifacts of the Chinese fishermen were provided by the generous curator of the San Diego Chinese Historical Museum, Murray Lee. Dr. May also assisted with this chapter and arranged artifacts of the nineteenth century Chinese fishing camps around Ballast Point for us to study and photograph.

The life of the waterfowl hunter was recreated and understood with the help Ron Vavra, a former duck hunter, who assisted us in creating the modern hunt, which involved shooting birds with cameras and binoculars in the early morning along the muddy shore of the Bay. He

also provided us with a biology teacher and numerous stories about duck hunting in San Diego County and raising the black brant in his backyard. We also thank Jim Brown of the U.S. Fish and Wildlife Service and former director of the San Diego City Lakes, for giving expert information about waterfowl hunting around "Duckville" and San Diego Bay. Mr. Brown also put us in touch with waterfowl legend, painter and decoy carver David Hagerbaumer, who provided us with an interview and permission to reproduce his beautiful artwork. Thanks to Jim Heather, a duck hunter and former Canadian biologist who visited our school and shared his stories about living with and studying the black brant of western Alaska.

Good fortune shined upon us with a chance encounter involving Frank Sherwood, professor emeritus of Florida State University, son of Dr. Clarence M. Sherwood, chief chemist, and head nurse, Mildred Persons Sherwood, of the Hercules gunpowder plant. He provided us with a direct connection to the workings of the WWI era gunpowder factory on the South Bay. Thanks go again to Dr. Sherwood for supplying us with historic photos of his family members at the Hercules plant along with a transcontinental interview. Barbara Moore, former program manager of Chula Vista Nature Center, gave us extensive information on the gunpowder factory and the present day nature center. Special thanks to Peter Neushul, professor of history at UC Santa Barbara, for his review of the kelp harvesting and extraction methods of Hercules.

The 76 years of the kelp harvesting industry for alginate production came to an end as we wrote this book and the story of its rise and fall was told to us in part by Dr. Craig Barilotti, Marine Resource Management Consultant for Sea Foam Enterprises, and former biologist at Kelco. We also thank him for critical review of this chapter. Further review was kindly provided by Andrew Currie, production manager of CP Kelco.

The rich history and contemporary operation of the South Bay Salt Works crystallized thanks to three important people. Thank you Allen M. Jones, vice president of H.G. Fenton, who opened the gates of the salt works and gave us insight into the process of salt production. Thank you Tracy Strahl, vice president of South Bay Salt Works, for giving us a tour around the facility; it gave us such a different perspective on the Bay. Also, thank you Victoria Touchstone, a National Wildlife Refuge planner for the U.S. Fish and Wildlife Service; without her we would not have been able to understand the biodiversity of the salt works past and present.

We were able to reconstruct the glory days of San Diego's tuna fishing industry with the help of long-time residents of San Diego, Jean Immenschuh and Guy Bruni. Both Immenschuh and Bruni shared with us colorful personal stories of the tuna fishing industry in San Diego that was such a big part of each of their lives, and they generously provided us with many beautiful and previously unpublished photos. We thank Russ Vetter of the Southwest Fisheries Science Center for informing of us of the biology of the tuna and the current state of research on this amazing predator and

important marine resource.

Our introduction to the Navy Marine Mammal Program (NMMP) was Phil Lamonica, a recently retired commanding officer of the Fleet ASW Base, and Tom Lapuzza, recently retired public affairs officer of the NMMP. We had the amazing opportunity to interview trainer DruAnn Clark, who shared the perspective of someone who has trained and escorted NMMP sea lions around the world. We would also like to thank Bob Lynch who took us out on the Bay and gave greater insight into the importance of the sea lions from the perspective of a former private employee.

Chris Harris, head biotechnician with the NMMP was a big help in getting extensive information on the daily treatment and training of the dolphins of San Diego. We would like to thank Jewyl Alderson, science teacher at High Tech High and former SeaWorld employee, for the insight related to the different positive reinforcement training methods for dolphins.

We were put in touch with literally thousands of white seabass with the help of Noelle Morris of the San Diego Oceans Foundation. We would also like to thank Gabe Buhr, recently retired Hubbs SeaWorld Research Institute (HSWRI) white seabass growout facilities manager, who showed us just how devoted the HSWRI and the Oceans Resources Enhancement Hatchery Program are towards restocking white seabass in San Diego Bay. And lastly, to Bob Hetzler, a former spearfisherman, who not only provided us with a fisherman's perspective and historical photos, but also noted the importance of restocking natural resources that have been depleted.

Several important individuals provided us with information on the natural history and local industry of the abalone. Thanks to David Lapota, from SPAWAR, who gave us a tour of the abalone-raising facilities near Ballast Point and for sharing photos of the outplanted abalone on the Pt. Loma kelp bed. Also, we acknowledge Howard Stacklin, who entertained us with colorful stories of his personal experience diving for abalone around San Diego Bay. And a special thanks to David Leighton, who reviewed this chapter and provided us wonderful photos.

The world of the bay mussel opened up for us with the assistance of Dr. Bonnie J. Becker, a former marine biologist at Cabrillo National Monument and a new faculty member of the University of Washington, Tacoma; John Davis, owner of Carlsbad Aquafarm; and Steve Le Page, the owner of M-Rep Consulting. Thanks to Laurel Rogers, U.S. Geological Survey, San Diego for providing us with the map used in the geography sections of the book. Special thanks to professor emeritus Richard "Pancho" Lantz for joining us on field outings and sharing his knowledge and passion for the creatures of the Bay.

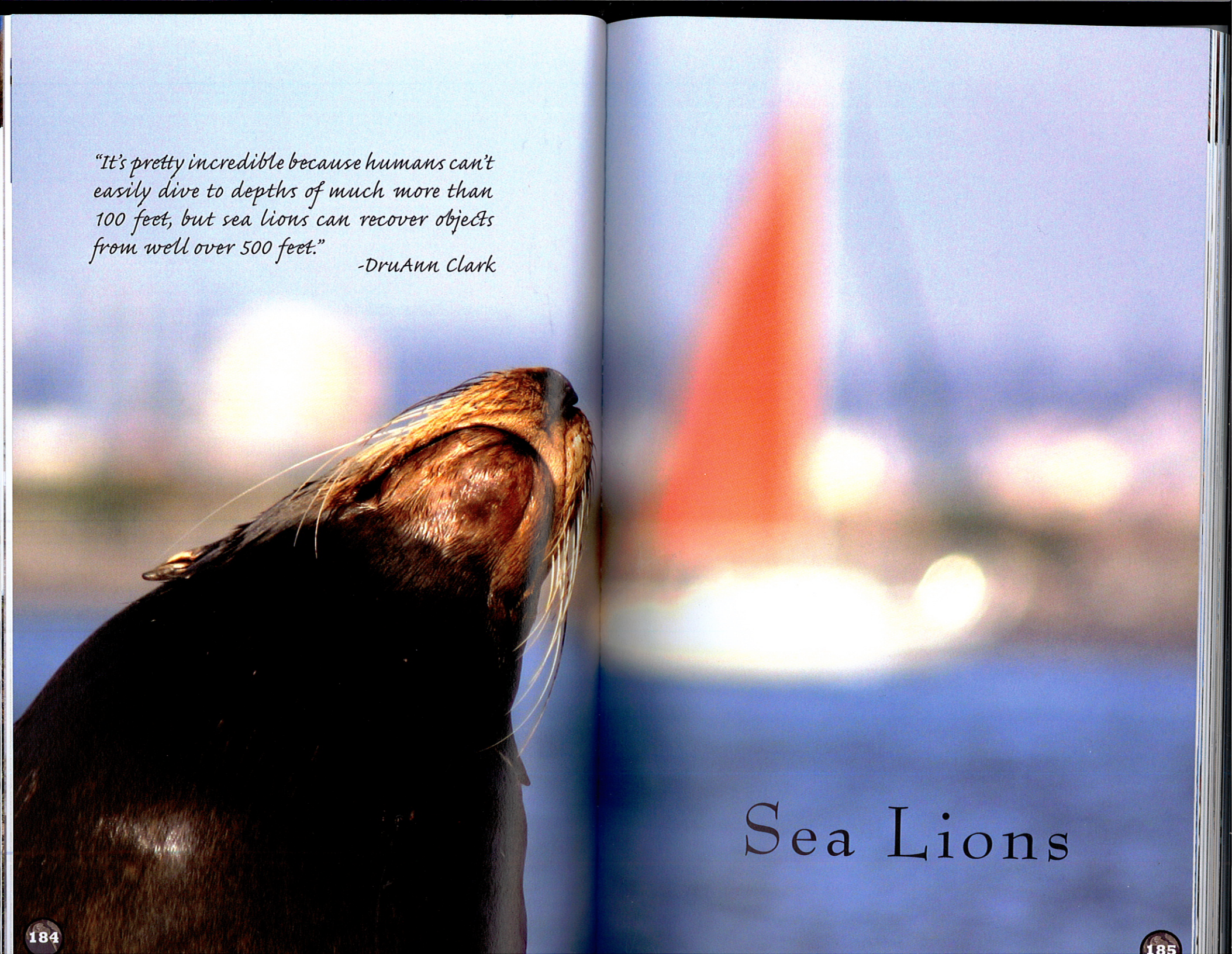
Thanks to graphic arts teacher David Jean for his expertise in the realm of design and for sharing his artistic vision. The technical aspects and logistics of conducting and transcribing over thirty in-the-field interviews for this book and for an upcoming documentary would not have been possible without the assistance and skills of multimedia teacher Blair Hatch.

We were able to photograph and understand the geography of the Bay with the aerial assistance of Captain Steve Byers and his float plane. Thanks to Chris Travers of the San Diego Historical Society for her assistance with the photo archives.

Lastly, we would like to recognize the student photographers who contributed a great deal to these pages with their wonderful imagery of San Diego Bay and the themes this book elaborates on. Many thanks go to: Erin Rexin, Chris Slater, Connie Han, Gwen Michael-Jones, Justin Cadlaon, Kris Keller, Hilary Dufour, Amelia Pludow, Charlie Ziman, Shawn Teeter, Justin Desagun and Moray Black.

"It's pretty incredible because humans can't easily dive to depths of much more than 100 feet, but sea lions can recover objects from well over 500 feet."

-DruAnn Clark

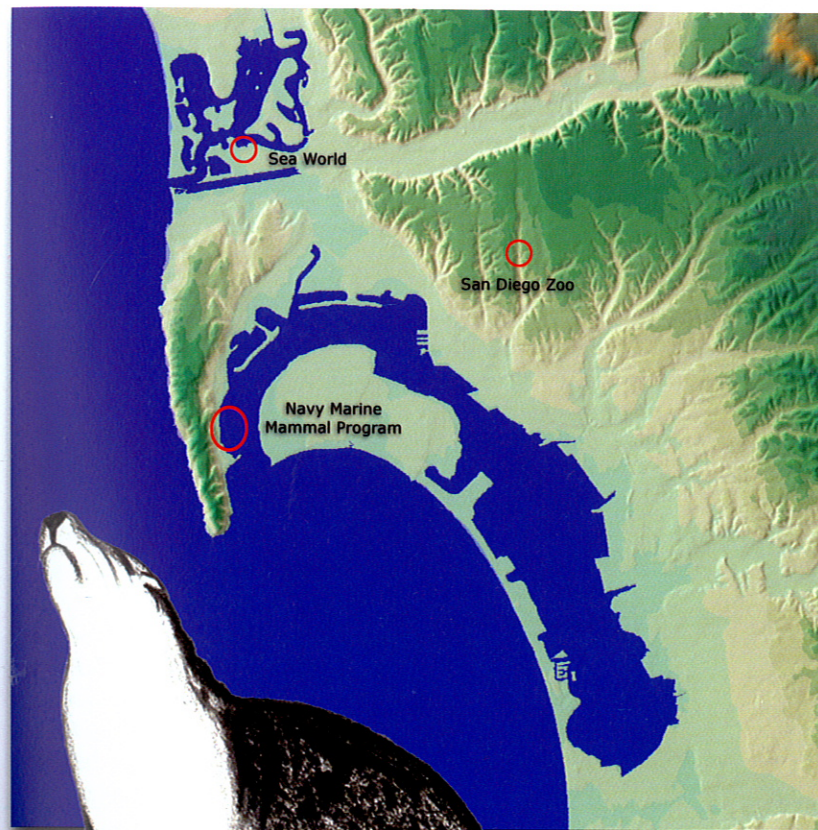


Sea Lions

Sea lions have many unique features that make them amenable for human use. They are able to traverse both land and sea, reaching depths their human partners cannot. For decades, man and sea lion have worked together as entertainers and, more recently, partners in the military's protection of our coasts. In the San Diego area, these hardworking and fiercely loyal animals are not only seen at the zoo and SeaWorld, entertaining the crowds, but also in San Diego Bay, where they are an integral part of the U.S. Navy Marine Mammal Program (NMMP).

Sea lions are used in the NMMP because they are friendly, easy to work with, can dive to great depths, and have superior low-light vision. Currently, there are about 30 sea lions working in the NMMP, trained to locate inanimate objects and carry out "force protection" measures used to reduce the risk of potential harm to the Navy's security forces. The sea lions that work with the Navy continually amaze their handlers with their intelligence and diligence, and these animals will undoubtedly continue to play an important part in the workings of the NMMP for a long time to come.

Geography of the Sea Lions of the Bay



Along with the wild sea lions that occasionally visit San Diego Bay, are trained sea lions that work in partnership with humans in the U.S. Navy. This human-sea lion interaction is put to work through the NMMP, located just north of Ballast Point along the coast of the Bay. There, the NMMP sea lions make their home and are often visited by their roaming brethren. SeaWorld and the San Diego Zoo are two other locations in the San Diego Bay area where interaction between sea lions and humans regularly occurs.

History of the Sea Lions of the Bay

Sea lions are one of the few animals that can capture our attention when we are young and keep it through our adulthood. Most often seen at zoos and marine parks, these creatures have amazing abilities that enable them to perfectly balance balls on their noses, balance on their front flippers, and jump over poles placed several feet above the water. We know sea lions for their intelligence and adaptability to living on land and in water.

Yet, despite the peaceable bond that exists between most humans and sea lions today, the first human interaction with sea lions occurred when they were hunted by mankind for food. Native American tribes along the West Coast of North America hunted sea lions, and used every part of them, wasting nothing. These early hunters harvested sea lions for their value as a food source, as well as their fur for clothing and shelter, their blubber and oil for fuel, and their bones fashioned into deadly weapons. Sea lion skin was often used to cover boats—their flippers as boot soles, their intestines as waterproof clothing, and their stomach lining as food storage containers. The Native Americans hunted the sea lions using primitive means such as clubbing them to death on land, or spearing them from their canoes. (Smith 1999)



about killing sea lions, because sea lions were thought to embody the souls of dead sailors. (Gordon 1994)

(Gordon 1994)

Over the years, many stories and myths about sea lions have been passed down. In northern Europe, sea lions were believed to be women and children condemned to a life of transience in which neither land nor sea could provide a permanent home. Sailors also had superstitions

When the first Europeans arrived on the West Coast of North America in the 18th century, these explorers used the Native American and Aleutian knowledge of animals and trapping to hunt and capture various sea mammals including sea lions. Soon, sea lions became an important resource for the fur trade. When Russians emigrated to America, the fur trade intensified and sea lions began to also be hunted for their oil. In those days, this oil was considered superior to whale oil. Moreover, certain parts of the sea lions were removed and sent to China to be used as aphrodisiacs. In the mid-1800s, marine mammal numbers dropped drastically along the West Coast of North America. As a result, the Europeans and Russians who had been deeply involved in industries that relied on sea lions moved on to other trades. (Coy 2002) (Folkens 2001) (Gordon 1994)

However, despite the brief respite, problems for sea lions arose again in the late 1890s when California fishermen began to complain about a decrease in the local fish supply, most notably with salmon. This decline was caused by overfishing in addition to the natural predator-prey relationship between sea lions and salmon. Often the sea lions would frustrate the fishermen further by stealing already hooked fish.

To mollify the fishermen, in 1899 the U.S. Fish and Game Commission passed a law that allowed the fishermen to shoot and kill any sea lion attempting to steal fish. In 1909, the act was repealed and a new law was put in place, this time outlawing the killing and capturing of California sea lions. Unfortunately, they continued to be hunted illegally until the 1960s. But in 1972 the Marine Mammal Protection Act was passed, providing them with protection from indiscriminate hunters. (Marine Mammal Protection Act 1994)

After many years of sea lion hunting, a new development occurred. California sea lions began to be captured, domesticated and used as a source of entertainment in circuses and zoos around the world. The first sea lion show was in 1933 at the Saint Louis Zoo in Missouri. The sea lion's name was Surfer and he was onstage for a full 27 minutes performing with rubber balls and clapping his flippers. Since then, sea lions have been trained to complete numerous other tasks, including balancing on their





front flippers, retrieving items, jumping over poles and balancing objects on their nose. In San Diego, the place to see these animals performing is at SeaWorld and the San Diego Zoo, where they perform in daily shows that display their natural abilities.

One of the more scientifically oriented advantages to keeping sea lions in captivity is the ability to study their anatomy and common ailments. Not all sea lions have a fruitful and healthy life, but those that live in places such as SeaWorld tend to live longer and be in better health than their wild or circus counterparts. Sea lions are still housed in many zoos and animal parks around the world. They continue to perform for human audiences and make children squeal with joy and exclaim in amazement. ("Sea Lion Arena" 2006)

As time passed, humans changed their attitudes concerning sea lions in captivity. Rather than focusing on showing off sea lions to the public, conservationists now concentrate on rescuing and rehabilitating marine creatures such as sea lions. Facilities like SeaWorld are now rescuing stranded, malnourished, sick, and injured animals, rehabilitating them, and releasing them back into the wild. Sea lions are also being used in the effort to educate the public on the impact of humans on marine life, as well as to study sea lion biology and diseases. ("California Sea Lions" 2006)

California sea lions are commonly seen around the bait barges of Mission Bay and San Diego Bay off Point Loma. There are even tours that will take people out to their rookeries for a closer look. In La Jolla, the sea lions, along with harbor seals, currently occupy the Children's Pool. In the past couple of years there has been much debate over whether they should continue to be allowed to stay there, sharing the beach with humans, or be kicked out completely. Debate has arisen over the decrease in water sanitation due to seal and sea lion fecal matter. However, even if it were to



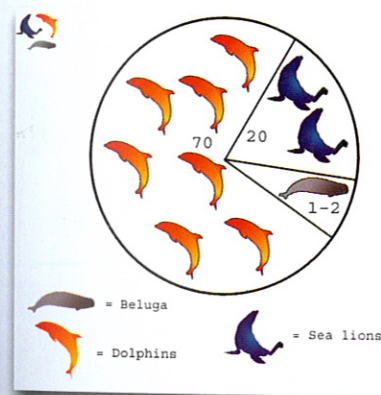
San Diego tourists admire the local sea lions lounging contentedly on the San Diego Bay bait barge.

be decided that the sea lions should move, the Marine Mammal Protection Act forbids any human disturbance. On the plus side, the Children's Pool provides a great area for tourists to come and observe them in their "natural habitat." (Marine Mammal Protection Act 1994)



Another concern over the sea lion residence in the area is the number of increased sightings of great white sharks, which are the primary predator of sea lions, along the coast of California. Within the past three years there have been several sightings of great white sharks off La Jolla. (Rogers 2003) (Moore 2006) (Daugherty 1979)

The Navy began to take an interest in using sea lions for military purposes in the seventies. After realizing the capabilities of these amazing creatures, they set up a program to study them—more specifically, their streamlined bodies—and apply the knowledge they gained from the study

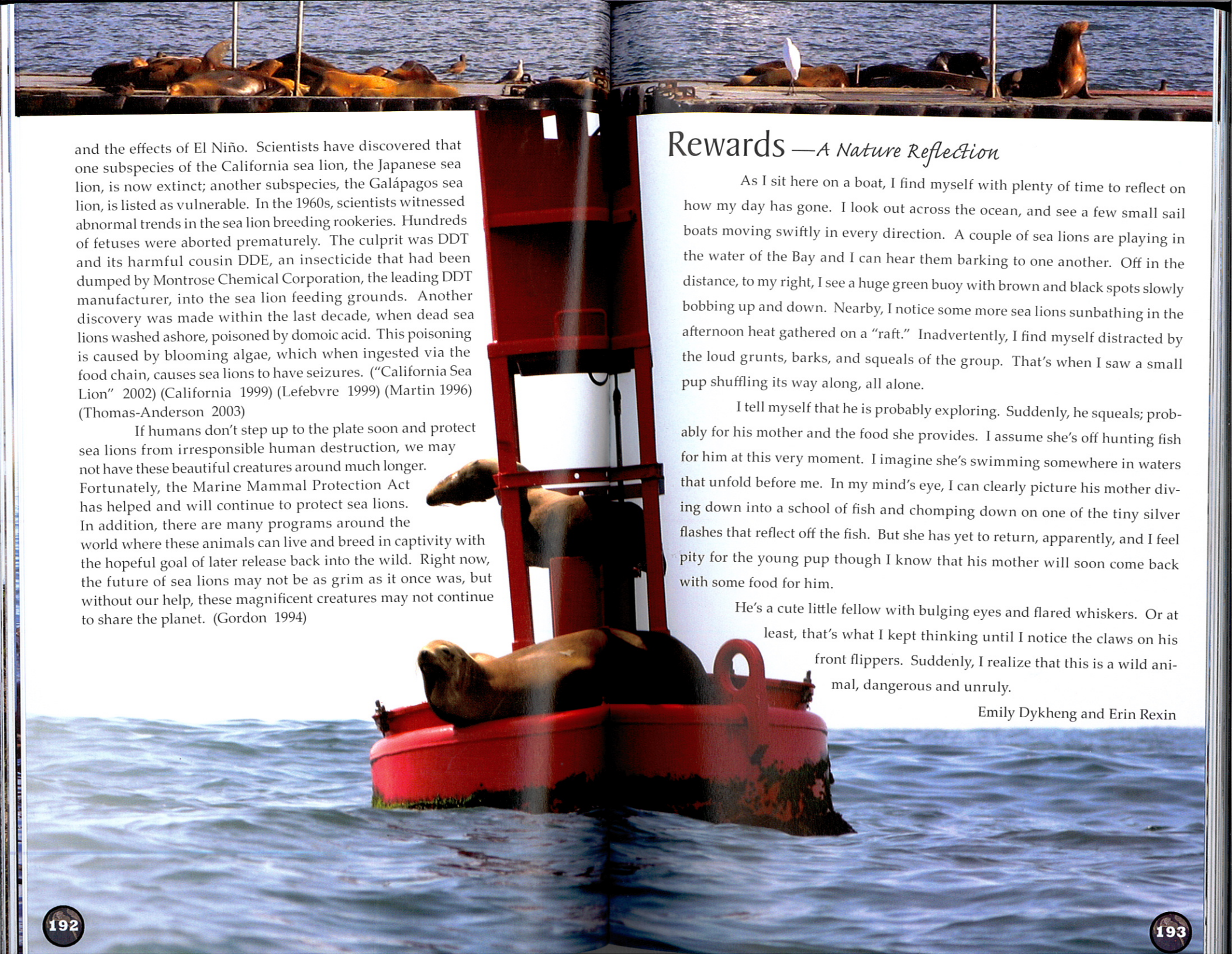


Distribution of marine mammals in the Navy's MK task forces.

to amplifying the Navy's marine warfare technology. Currently, a number of talented sea lions are being used in the NMMP to conduct various activities, including hunting and locating training mines and enemy divers, and protecting docks where U.S. ships come into port. Under the program, they are grouped into one of two special task forces, designated MK5 and MK6. MK5 consists solely of sea lions whose task is to find and recover objects from the bottom of the ocean, while MK6 uses both sea lions and dolphins for force

protection. The sea lions were most recently used in Bahrain during Operation Iraqi Freedom. They protect Navy vessels by acting as lookouts for enemy swimmers or divers. (Bonner 1994) (Clark 2006) (Lynch 2006)

As humans learn more about the California sea lion, they have come to recognize several distinctive features about them and their survival rates. New information is being released on the death of these animals due to pollution, fishing nets, fishing hooks, domoic acid poisoning, disease,



and the effects of El Niño. Scientists have discovered that one subspecies of the California sea lion, the Japanese sea lion, is now extinct; another subspecies, the Galápagos sea lion, is listed as vulnerable. In the 1960s, scientists witnessed abnormal trends in the sea lion breeding rookeries. Hundreds of fetuses were aborted prematurely. The culprit was DDT and its harmful cousin DDE, an insecticide that had been dumped by Montrose Chemical Corporation, the leading DDT manufacturer, into the sea lion feeding grounds. Another discovery was made within the last decade, when dead sea lions washed ashore, poisoned by domoic acid. This poisoning is caused by blooming algae, which when ingested via the food chain, causes sea lions to have seizures. ("California Sea Lion" 2002) (California 1999) (Lefebvre 1999) (Martin 1996) (Thomas-Anderson 2003)

If humans don't step up to the plate soon and protect sea lions from irresponsible human destruction, we may not have these beautiful creatures around much longer. Fortunately, the Marine Mammal Protection Act has helped and will continue to protect sea lions. In addition, there are many programs around the world where these animals can live and breed in captivity with the hopeful goal of later release back into the wild. Right now, the future of sea lions may not be as grim as it once was, but without our help, these magnificent creatures may not continue to share the planet. (Gordon 1994)

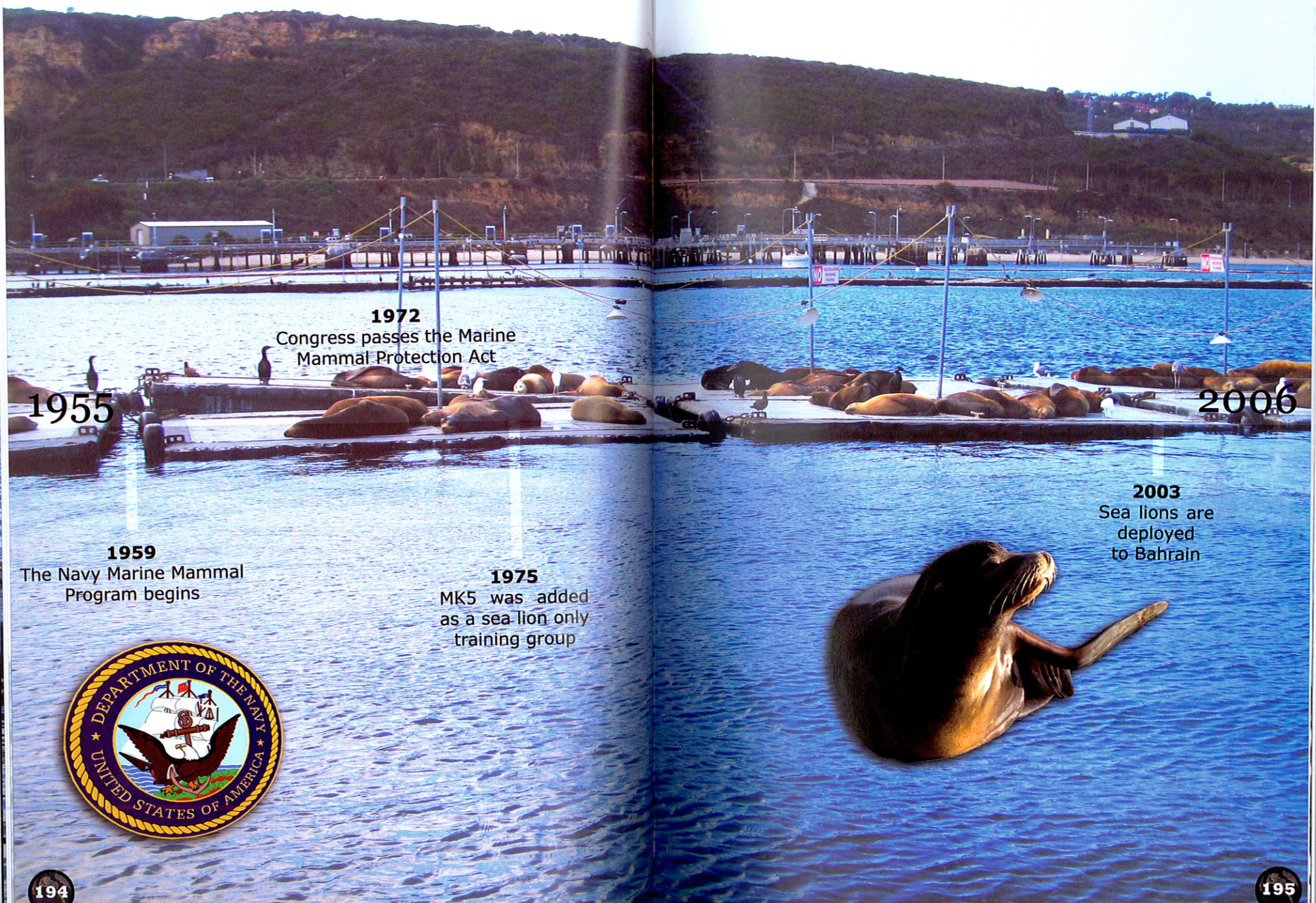
Rewards — *A Nature Reflection*

As I sit here on a boat, I find myself with plenty of time to reflect on how my day has gone. I look out across the ocean, and see a few small sail boats moving swiftly in every direction. A couple of sea lions are playing in the water of the Bay and I can hear them barking to one another. Off in the distance, to my right, I see a huge green buoy with brown and black spots slowly bobbing up and down. Nearby, I notice some more sea lions sunbathing in the afternoon heat gathered on a "raft." Inadvertently, I find myself distracted by the loud grunts, barks, and squeals of the group. That's when I saw a small pup shuffling its way along, all alone.

I tell myself that he is probably exploring. Suddenly, he squeals; probably for his mother and the food she provides. I assume she's off hunting fish for him at this very moment. I imagine she's swimming somewhere in waters that unfold before me. In my mind's eye, I can clearly picture his mother diving down into a school of fish and chomping down on one of the tiny silver flashes that reflect off the fish. But she has yet to return, apparently, and I feel pity for the young pup though I know that his mother will soon come back with some food for him.

He's a cute little fellow with bulging eyes and flared whiskers. Or at least, that's what I kept thinking until I notice the claws on his front flippers. Suddenly, I realize that this is a wild animal, dangerous and unruly.

Emily Dykheng and Erin Rexin



1955

1972
Congress passes the Marine Mammal Protection Act

2006

1959
The Navy Marine Mammal Program begins

1975
MK5 was added as a sea lion only training group

2003
Sea lions are deployed to Bahrain





DruAnn Clark

We set up our equipment for our interview with DruAnn Clark on a patch of grass overlooking San Diego Bay, adjacent to the sea lion cages. The sun was shining brilliantly, and its reflection on the water of the Bay created a great ambiance for the interview. In front of us, about 300 yards away, were the dolphin pens of the Navy Marine Mammal Program (NMMP).

We sought out Ms. Clark because of her experience as a trainer of sea lions in San Diego Bay and abroad in places such as Iraq, during Operation Iraqi Freedom. She is a Navy civilian and works for the NMMP. As a child, she dreamed of becoming an animal trainer. She obtained her bachelor's degree in animal behavior and began working with marine mammals at the Walt Disney World—Living Seas facility in Florida. Once Ms. Clark heard about the NMMP in San Diego she decided to move west to California. She initially worked with dolphins but soon switched to sea lions, which she found she enjoys immensely.

Student Researcher (SR): Why are the sea lions preferred over human divers?

DruAnn Clark: Well, we have the sea lions doing tasks that humans aren't that good at—tasks like object recovery. Humans can't dive down to 500 feet and recover objects that are on the bottom of the ocean in some of the low-level light situations. Humans can't see in the dark very well, whereas sea lions are very good at it. ... In fact, [the sea lions'] force protection job is best utilized at night. ... During the day humans can see well, but at night we are able to utilize the sea lions low-light vision. So, actually, a lot of the sea lion's training happens at night. ... Recovering objects from the bottom of the ocean is really an amazing task that our sea lions do. It's pretty incredible because humans can't easily dive to depths much more than 100 feet, but sea

lions can recover objects [at depths of] 500 feet. They are also able to do repetitive dives to those depths.

SR: How long does it take to train an individual animal?

Clark: It depends on the task they are learning. Just like humans, they learn at different rates [depending] on how hard the task is. But



Sea lion training dummy—friend or foe?

they do start their training at a young age, and we start interacting with them right away, so they learn their basic husbandry behaviors. ... Husbandry behaviors are behaviors that we teach them [in order] to better care for them. For example, we teach them how to open up their mouths so that we can look inside and check their teeth.

We use a method called "operant conditioning," which is the use of positive reinforcement. We reinforce the good behaviors and ignore the inappropriate behaviors.

SR: Do you train the sea lions differently from the dolphins?

Clark: Oh, very much. Since sea lions can walk on land they are very different [in the] way that you can interact with them. However, the basic principles of training—of operant conditioning—are the same whether it is a sea lion or a dolphin. It's all positive reinforcement.

SEA LIONS	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9	10/10	10/11	10/12	10/13	10/14	10/15	10/16	10/17	10/18	10/19	10/20	10/21	10/22	10/23	10/24	10/25	10/26	10/27	10/28	10/29	10/30	10/31		
Liberty																																	
Newman																																	
Iceman																																	
Martin																																	
Strober																																	
Grenlin																																	
Rambo																																	
Nick																																	
TOTAL																																	

Feeding regimes for "Reagan" and "Top Gun" platoon sea lions.

SR: Do they do any training on land?

Clark: Actually, they do quite a bit of training on land. A lot of their tasks [require] them to ride in boats to go from one place to another. Sometimes they [walk] up piers and onto the beaches. So, all that's done above the water.

SR: Do the sea lions ever get distracted by the noise?

Clark: That's actually one of the things we need to desensitize them to, since the sea lions are going to be traveling all around the world and working ... in [a lot] of different situations with [a lot] of different noises. We want to them to get used to helicopters flying overhead and boats going by and different people around. We want to desensitize them to that.

SR: When the sea lions are going out and doing their operations, do they do it in groups or individually?

Clark: It really depends on what tasks they're doing. Sometimes the sea lions work in a team, and sometimes the sea lions work individually. The sea lions are very adaptable and very good at the job that they do. So, really, they can do it in any one of those circumstances.

SR: What exactly do the sea lions do?

Clark: There are two different projects that the sea lions focus their attention on. The first project is an object recovery project where they recover objects that the Navy has put down at the bottom of the ocean at [great] depths,

depths that are far too deep for [human] divers. So, the sea lions go down and attach a grabber to an object that's attached to a line. ... These are objects that otherwise, in the past, would be unrecoverable; they [would] go down to the bottom of the ocean and just stay there. The sea lions are very good at going down and picking up these objects from the bottom and attaching these recovery lines. The second project that the sea lions work on is a force protection project where the sea lions serve as sentries, as part of a security team, and go out and search for enemy swimmers or divers coming up to a pier. They protect piers and anchorage areas for U.S. Navy vessels.

SR: Have the enemy divers ever hurt the sea lions?

Clark: The sea lions are very good at their jobs and they are actually trained to ... detect a swimmer or diver without being detected themselves. So, they go in, and they just let us know that somebody's there. A security team then goes in and takes care of the enemy swimmer or diver.



The pens housing the Navy sea lions.

SR: Do you keep trained and wild sea lions apart? Would they be able to mate or play with each other?

Clark: Our sea lions live in water pens right here in San Diego Bay. The wild sea lions often do come up and take naps on our docks right

next to our sea lions; so, they do get to see each other, as well as when they are out in the open ocean. Our sea lions sometimes interact with the wild sea lions.

SR: Were the sea lions ever used in the war with Iraq?

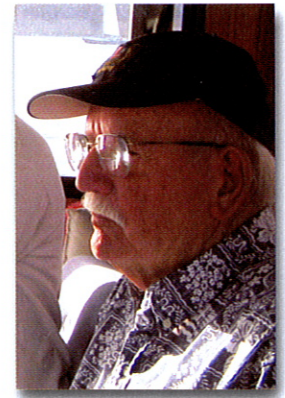
Clark: The sea lions were deployed in 2003 during Operation Enduring Freedom, and the sea lions were used to protect a pier where U.S. Navy sea vessels were kept. So, yes—the sea lions were used at that time.

SR: So, sea lions are used in the war that is going on? In what other ways are they used?

Clark: When [the sea lions] were deployed, they did a task where they would search out a pier area for enemy swimmers or divers. They did an excellent, excellent job at protecting U.S. Navy vessels and saving U.S. lives.

Bob Lynch

On a sunny and warm day, our group interviewed Bob Lynch on his boat at the San Diego Yacht Club. We sought him out because of his knowledge of San Diego Bay and his experience with ordnance recovery by sea lions. During World War II, Mr. Lynch enlisted in the U.S. Army and became a radio technician. Although he never saw combat, he remained in the armed services until just before the Korean War. After leaving the Army, he worked for General Dynamics. Throughout his career, Mr. Lynch had worked on several military aeronautical projects,



the most famous of which was the Tomahawk cruise missile.

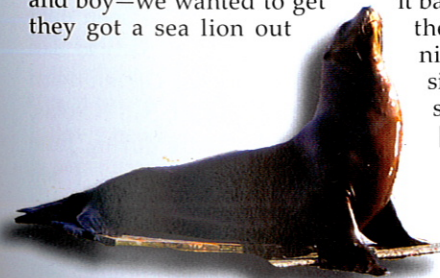
We didn't begin the interview until after Mr. Lynch had maneuvered his boat through the waters off the coast of Point Loma, where the naval base is located, and masterfully steered the vessel into its designated dock. The interview took place in the cabin of his boat, and though it lasted only a few minutes, the information we received was unique, exciting, and invaluable.



Mr. Lynch and students from High Tech High cruising the Bay on his boat prior to the interview.

Student Researcher (SR): What kind of industry are the sea lions living in San Diego Bay involved in?

Bob Lynch: Well, there [are a lot] of industries on San Diego Bay associated with the Bay, but one of the most interesting is the training of the sea lions—and that's done right out here, off Point Loma. They train them for all sorts of Naval duties: searching the harbor bottom for aliens, looking at the hulls of ships, and retrieving things from the bottom. Anyway, I had one experience... We were launching a missile out at San Clemente Island—and San Clemente Island is way out of San Diego—about 70 miles—and the missile did not work like we thought it should; and it dove in 1,000 feet of water, and boy—we wanted to get it back to figure out what happened. So, they got a sea lion out there, and they gave him a couple of nice fish and told him: "Go get that missile." They put a harness on his nose so that he dove down 1,000 feet and [clamped] the line onto the missile. In that way, we were able to recover the missile—and that probably saved us a couple million dollars. So, that's the kind of industry we have here in San Diego Bay.





Biology of the California Sea Lion

Consider the best characteristics of a beloved childhood pet or a hardworking drug-sniffing dog. The beneficial traits of these clever critters are rivaled by those found in the California sea lion (*Zalophus californianus*). Even their facial features resemble those of our canine companions. Showing lovable dog-like loyalty as well, sea lions have established themselves as allies with the U.S. Navy. Their ability to thrive in both marine and terrestrial environments makes them truly extraordinary creatures and provides their human associates with grounds for continued partnership and cooperation.

Sea lions are classified as pinnipeds, meaning “fin-footed.” There are three genera in the pinniped family: *Phocidae* (true seals), *Odobenidae* (walruses), and *Otariidae* (sea lions). Grouped together with sea lions under the *Otariidae* genus are fur seals and eared seals. Sea lions can be distinguished from fur and eared seals by two of their unique physical features: they have an external ear flap, and their hind feet can rotate forward to help them with locomotion on land. There are five different species of sea lions that live in various locations around the world. These species are: the New Zealand sea lion, the Australian sea lion, the South American sea lion, the Stellar sea lion, and the California sea lion. (Bonner 1994) (Myers 2000) (“The Pinnipeds...” 2006)

The California sea lion has the greatest range of all sea lions, traveling from northern Baja Mexico to British Columbia and west to the Galápagos Islands and Japan. The California sea lion tends to reside where there is a lot of human activity and coastal construction. They live and breed near piers, buoys, jetties, and platforms. They can be seen near settlements everywhere from the Tres Marias Islands in Mexico to San Diego and San Francisco, California and Vancouver, Canada. Off Southern California, there are four main breeding places: San Miguel, San Nicolas, Santa Barbara, and San Clemente. Pupping season occurs during June and July, and pups stay with their mothers for six months or longer. (“Sea Lions” 1999)

California sea lions inhabit rocky shore and sandy beaches of coastal islands and the mainland. Adult males weigh up to 1,000 lbs. Females can

weigh up to 220 lbs. Males have a dark brown coat with a lighter patch or mane on their heads. Females range from light to dark brown in color. As males mature, the tops of their heads get lighter. At the age of five, males develop a sagittal crest, a bony bump on the top of the skull that becomes more prominent with age.

California sea lions’ diet consists of fish, lamprey, shellfish, and octopi. They will consume 9 to 31 lbs of fish daily. If properly nourished, they can live about 25 years. They have few predators, besides killer whales, great white sharks, and angry fishermen. The California sea lion is intelligent and well adapted, and many



fishermen can relate stories of their mischievous nature. (“California Sea Lion” 2002) (Daugherty 1979)

Sea lions are very social animals that live in large groups. These groups often rest or float together on the ocean’s surface, on “rafts,” or on shore. While resting on rocks or the shoreline, sea lions point their noses skyward and are



sometimes seen lying atop one another. They are also seen playing and leaping together on the surface while “rafting.” (“California Sea Lions” 2006)

When they choose to walk on land, sea lions’ short fur protects their skin as they traverse across rocks and other surfaces. Their top speed across smooth rocks may reach up to 15 mph, but can only be maintained for a few yards. Underwater, sea lions propel themselves through the water using their long front flippers. Their back flippers are not used much in actual swimming propulsion, but instead act as stabilizers. Their maximum speed underwater is about 25 mph. Their dives often reach depths of 800 feet, although most dives don’t exceed 360 feet. (“San Diego Harbor...” 2006)

Sea lions use four different kinds of vocalizations when they get aggressive. There is the bark, squeal, belch, and growl. When two competing females are close together, their bark serves as a long-distance threat to other sea lions. Their squeal is made with a wide-open mouth that follows head-weaving behavior. The belch is somewhat more intense and is accompanied by forward thrusting of the head. The most intense vocal threat is a growl. The growl has a harsh quality and is often used during actual physical fighting.

Captive sea lions perform the tricks or specific tasks they need

to survive. Training starts when they are young and may take up to ten years. Sea lions are trained to recognize hand gestures, numbers, and letters.



A bull sea lion displaying "belch" communication.

Vocalization, where the trainer says words like "ball" or "cube," is also used. During one series of experiments at the University of California's Long Marine Lab in Santa Cruz, a female sea lion learned how to respond to more than 20 hand gestures.

Sea lions have poor vision on land, and the range of their eyesight is very limited. Males can see up to 82 yards in daylight and 27

yards on a clear night. Females will become agitated if a creature approaches them within a few yards. When a strange object is near or approaching, a sea lion extends its neck and moves its head from side to side. But even though sea lions have poor vision, they can see shapes or outlines.

The great success in captive breeding programs within marine parks has made live capture for public display purposes unnecessary. Birthing takes place approximately 50 weeks after breeding. Pups weigh up to 16 pounds at birth and are nursed for at least five or six months—sometimes for over a year. During mating season, males guard their territories and bark almost continuously. Sea lions are very vocal and the pups have a bleat-like call. Mothers recognize their pups on crowded rafts or shore through smell, sight, and vocalizations. At an early stage pups also learn how to recognize their mother's vocalizations. ("California Sea Lion" 2002) ("San Diego Harbor..." 2006)

The biggest problem for these sea lions is weather conditions produced by El Niño, as during these events, warmer water causes the sea lions' prey to reside in deeper water. This forces sea lions to swim further from shore and dive to greater depths in order to feed. For younger, more inexperienced sea lions and pups this can cause problems. Many of these sea lions starve or can become separated from their mothers. (Rocca 1998) ("Stellar Sea Lions" 2006) (Kay 1998)

Hear the Wild

We are the life that brings

We are the ones that bark

Not the ones that sing

Not the ones that talk

And the water, that's what we need

But the docks, that's where we eat, sleep and breathe

That's where we lay until humans try and deceive

We play the side lines: watch, bark and retrieve

This is our nature

These are the things we do

You would do the same if someone tried to jeopardize you

We bark as strong as iron

The *Zalophus californianus*

A.k.a., the California Sea Lion

Moe Black



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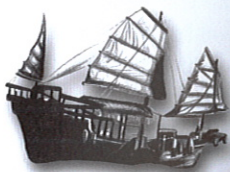
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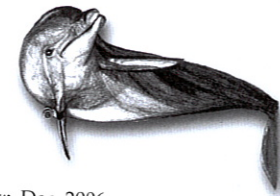


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High Tech High: pages 36–43 (uppermost), 38, 39, 40 (bottom), 42, 43 (bottom), 44 (third image down), 45 (top right), 46, 48, 50 (top and bottom), 51 (top and bottom), 52, 53 (top and bottom), 54 (top, middle, and bottom), 55 (top), 56, and 57.

Regulatory Fish Encyclopedia: page 55.

San Diego Historical Society: pages 32–33, 37, 40 (top), 43 (top), 44–45, 44 (top left), 47, and 49.

Waterfowl Hunting

Courtesy of David Hagerbaumer: pages 60, 64 (bottom), 67 (bottom), 70, 71, 72.

Courtesy of Jim Brown: page 73.

Courtesy of Jim Heather: pages 79 (top and bottom), and 80.

Courtesy of Ron Vavra: pages 65 (bottom), and 75.

High Tech High: pages 58–59, 61, 62–67 (uppermost), 62 (top and bottom), 63 (bottom), 64 (top), 65 (top), 66 (top and bottom), 67 (top), 68–69, 68, 69 (top, middle, and bottom), 74, 77, 78, 79 (top and bottom), 81–82 (top and bottom), 83 (top and bottom), and 84–85.

San Diego Historical Society: page 63 (top).

Tuna

Courtesy of Guy Bruni: pages 86–87 (photographed by Guy Bruni), 90, 93, 94, 107 (top and bottom), 108, 109, and 110 (top and bottom).

Courtesy of Jean Immenschuh: pages 92, 98, 100 (top and bottom), 101, 102, and 103 (top).

Courtesy of Russ Vetter: page 104 (top).

FAO/SIDP Species Identification Sheets: pages 112 (middle) and 113 (middle).

High Tech High: pages 88, 90–97 (uppermost), 95, 96, 97, 98–99, 99, 103 (bottom), 104 (bottom), 105, 106 (top and bottom), 111, 112 (top and bottom), and 113 (bottom).

NOAA Fisheries Collection: page 113 (top).

Salt

San Diego Historical Society: page 91.

Courtesy of Allen Jones: page 128 (top).

Courtesy of Jean Immenschuh: 127 (top).

Courtesy of Western Salt Company: pages 116, 119, 123, 126 (bottom), 128 (bottom), and 129.

High Tech High: pages 114–115, 118–124 (uppermost), 118, 120, 121, 122, 124, 125, 126–127, 126 (top), 127 (middle and bottom), 130, 131, 132 (top and bottom), 133, 134, 135, 136, 137, 138 (top and middle), 139 (top and bottom), 140 (top, middle, and bottom), 141 (top and bottom), 142 (top and bottom), and 143 (top and bottom).

Photographed by John Good: page 138 (bottom).

Kelp Additives

High Tech High: pages 144–145, 146, 147 (bottom), 148–151 (uppermost), 148, 149, 150, 151, 152–153, 152, 153 (top and bottom), 154 (top and bottom), 155, 156, 157 (top and bottom), 158 (top, middle, and bottom), and 159 (top and bottom).

Kelp to Gunpowder

Courtesy of Dr. Frank Sherwood: pages 168, 177, 179, and 180 (top).

High Tech High: pages 162, 163 (bottom), 164–171 (uppermost), 164, 167 (top), 169, 170 (top and bottom), 171, 172–173, 172 (top, middle, and bottom), 173 (top and bottom), 174, 175, 176 (top and bottom), 178, 180 (bottom), 181, 182 (top and bottom), and 183 (top and bottom).

San Diego Historical Society: pages 160–161, and 166–167.

Sea Lions

High Tech High: pages 184–185, 186, 187 (bottom), 188–193 (uppermost), 188 (top and bottom), 189, 190, 191, 192–193, 194–195, 194, 195, 196 (top and bottom), 197, 198, 199 (top, middle, and bottom), 200, 201 (top and bottom), 202, and 203.

Dolphins

Courtesy of Dave Koontz: page 220 (bottom).

High Tech High: pages 204–205, 206, 207 (bottom), 208–215 (uppermost), 209, 210 (HTH archives), 211, 212, 215, 216–217, 217, 218 (top and bottom), 219 (top and bottom), 220 (top), 221 (top and bottom), 222, 223 (top and bottom), 224 (top and bottom), 225, 226 (top and bottom), 227 (top and bottom), 228 (top and bottom), and 229.

White Seabass

Courtesy of Bob Hetzler: page 251.

High Tech High: pages 230–231, 232, 233 (bottom), 234–239, 234, 235, 236, 237, 238 (top and bottom), 239, 240–241, 241, 242 (top and bottom), 243, 244 (top and bottom), 245, 246 (top and bottom), 247 (top and bottom), 248, 249 (top and bottom), 250 (top and bottom), 252, 253, 254 (top, middle, and bottom), and 255.

Abalone

Courtesy of David Leighton: pages 273 (top and bottom), 275, and 280.

High Tech High: pages 256–257, 258, 260–265 (uppermost), 261, 262, 264, 265, 266–267, 266, 267, 268, 269, 270 (top and bottom), 271, 272, 274, 276, 277, 278 (top and bottom), 279 (top and bottom), and 281.

San Diego Historical Society: page 263.

Mussels

High Tech High: pages 282–283, 284, 286–291 (uppermost), 287, 288 (top and bottom), 289, 290, 291, 292–293, 292 (top and bottom), 293, 294, 295, 296, 297, 298, 299 (top and bottom), 300 (top and bottom), 301–303.

